

Evaluation of Three Relative Abundance Indices for Assessing Dingo Populations

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Abstract

Three methods of assessing relative abundance of wild canids were evaluated on a population of dingoes, *Canis lupus dingo* (Corbett), on a cattle station in south-western Queensland. The tested indices relied on measurements of activity based on spoor. Two of the techniques attracted the target species to tracking stations through the use of a novel (fatty acid scent) or food-based (buried meat) attractant. The third index (activity) measured the number of dingo tracks crossing tracking stations placed at 1-km intervals along a road transect.

All three indices had a high level of agreement for detecting differences in relative abundance, with correlation coefficients exceeding 0.85. When the stations were analysed in 1-km segments, the activity index proved the most sensitive, producing proportionally more positive responses than either of the other two indices irrespective of whether the tracking stations were assessed at 1-, 2-, 3- or 4-day intervals.

Inconsistencies between indices existed, with the derived abundance indices not showing the anticipated reduction following population reduction. The effect of season and the interaction between dingo activity and index methodology are discussed.

Introduction

Estimates of absolute density are usually difficult and expensive to obtain and often unnecessary (Caughley 1977). Pelton and Marcum (1977) describe five difficulties in assessing the abundance of carnivore populations: (1) relatively sparse populations; (2) large home ranges and movement patterns of individual animals; (3) secretive behaviour; (4) occurrence in rough terrain, inaccessible to the researcher; and (5) the difficulty of capture-observation or recapture and re-observation. Consequently, researchers and land managers rely on indirect methods of obtaining measurements of carnivore abundance.

Throughout Australia, studies have been conducted on wild canids using a variety of methods to assess relative abundance, including visitation rate to bait stations (Thompson and Fleming 1994), a cyanide index (Algar and Kinnear 1992), questionnaire survey of spoor and howling (Mitchell *et al.* 1982) and activity around water facilities (Best *et al.* 1974).

For experiments that measure the impact of control programmes, compare pre- and post-control populations, or monitor and compare abundance over seasons or longer time frames, the relative abundance methodology should be rapid and simple, yet sufficiently sensitive to reflect changes in the population density over space and time. In this experiment we compared three methods of assessing the relative abundance of dingoes, *Canis lupus dingo*, to determine (1) the method(s) most sensitive to dingo activity, (2) the optimum period between assessments, and (3) the advantages and disadvantages of each technique.

Methods

Two 50-km transects, separated by a 10–15-km buffer, were established along vehicle tracks throughout an extensive beef cattle property of 800 km² in the Upper Maranoa catchment of south-western Queensland (25°30'S, 147°45'E). The buffer was imposed to ensure the areas were independent (Thomson 1987, 1992b). Each kilometre of the transect contained three types of stations assessing relative abundance.

Fatty Acid Scent (FAS) Index

The Scent Station or FAS index was for many years used for monitoring coyote abundance in western USA (Linhart and Knowlton 1975; Roughton and Sweeny 1979). We used a modification similar to the methodology used in Allen *et al.* (1989). The visitation rate of dingoes to tracking stations (each 1 m² of raked earth), one located every 500 m on alternate sides of vehicle tracks, 1–3 m off the wheel tracks, was monitored. In the centre of each tracking station was placed a plaster disc, approximately 20 mm in diameter and 5 mm thick, impregnated with FAS (Roughton and Sweeny 1982).

Discs were prepared in a laboratory prior to the field trial as follows. After casting, the discs were placed in a glass chamber that was continuously evacuated for 30 min to remove residual odours. Following evacuation, the discs were returned to atmospheric pressure and soaked in FAS solution for 60 min. They were then removed from the solution, drained and packed in sealed bottles. In the field, the discs were removed and placed on the tracking station by means of tweezers or plastic gloves.

Tracking stations were checked daily and FAS discs were replaced every 48–72 h. Dingo responses to FAS (and buried meat) stations made it impractical to separate superimposed tracks (dingoes scratched, rolled, urinated and generally wrecked the tracking station), so no attempt was made to identify whether more than one dingo visited a station within a 24-h period. Stations were inspected and recorded as either a positive or negative response for dingo activity.

Buried Meat (BM) Index

One piece (50–100 g) of fresh, boneless kangaroo meat was buried (5–10 cm) in the centre of 1 m² of raked earth every 500 m on alternate sides of the transect (250 m away from the nearest FAS station). Burying baits results in no significant differences in the number of baits found by dingoes yet deters removal by birds and other non-target animals (Allen *et al.* 1989). Assessment methods were identical to those for the above FAS index.

Activity Index

At 1-km intervals along the transect and at a distance of no less than 10 m from the closest FAS or BM station, a swathe 1 m wide was raked across the road from gutter to gutter. Where the road surface was too hard and/or vegetated, the vegetation was removed and a fine dust or sand was sieved over the surface.

Tracking stations were monitored and swept daily and the number of dingo tracks crossing the 50 tracking stations each day was recorded. The activity index was calculated as the mean number of tracks per transect per day.

General Procedures

A mark was made discreetly in the corner of each tracking station. This mark was used as a gauge to determine whether rain, livestock or vehicle activity had obliterated all traces of spoor (Smith *et al.* 1994). If the mark could not be clearly discerned the following day the station was removed from the calculations. If other animals had removed either the FAS disc or the meat, this was recorded.

The three indices varied in their manner of operation, two requiring an active response by dingoes to either a food reward (the meat), or a novel odour or object (the FAS disc). The activity index was a passive system requiring only the dingoes' movement across the tracking station.

In each of the two treatment areas, 100 FAS stations, 100 BM stations and 50 activity stations were established along a continuous transect of 50 km.

The number of positive responses (FAS and BM indices) and dingo tracks (activity index) were summed for each day and averaged over the number of days on which readable stations were assessed. When the previous day's cumulative mean varied 10% or less from the current cumulative mean, we defined that mean to be the cut-off value at that density level.

Use of this criterion, although arbitrary, is both intuitive and pragmatic. The practical reality is that monitoring in the field has to stop sometime; it makes sense that this occurs when the most recent change to the cumulative mean is only a small proportion (<10%) of that mean.

To meet the objectives of this experiment and compare the sensitivity of the three indices, it was not essential to reach this arbitrary stopping point at each density level for each of the indices. However, this was achieved for nearly all the indices at each density level.

Population Disturbances

To simulate three densities of dingoes, the population at each site was reduced by laying 1080-poisoned baits along the two 50-km transects. Prior to laying the poisoned baits, the unpoisoned pieces of meat used in the BM index were removed. One poisoned bait (6.0 mg 1080 per bait, injected) was laid every kilometre and collected 24 h later.

After both sites had been poisoned, the three indices were recalculated. The process was then repeated but the baiting intensity was increased, poisoned baits being laid every 500 m and exposed for 48 h. Poisoned baits removed in the first 24 h were replaced. At the completion of the two baiting periods, the poisoned baits were collected and destroyed.

Data Analysis

To obtain an indication of which method was most sensitive to the presence of dingoes, contiguous 1-km segments, each having the data from one station from each index method, were used as units for comparing whether the three abundance indices gave the same proportion of positive results. Indices were compared for single days and for groups of two, three and four consecutive days to determine the optimal interval between reading stations. If a station was read as positive for any day among a multiple-day grouping, it was considered positive for that multiple-day period. This assumes that the results for each grouping of days would have been the same if the stations had been read only at the end of the multiple-day period rather than every day. This process reduces the data recorded for activity stations (numbers of dingo tracks per tracking station) to positive and negative responses, so that the three indices could be compared for sensitivity to dingo presence.

Cochran's *Q*-test for testing correlated proportions (e.g. Winer 1971) was used to analyse the binary (1 = positive, 0 = negative) data, where the three index methods were repeated measures on each 1-km segment. Separate analyses were performed for each grouping of days on each of the two sites.

Results

Except when rain reduced the number of readable stations to a point (>10% unreadable) where the data from that day were dropped, all three indices reached the arbitrary cut-off point in either four or five days.

We recorded up to eight dingo tracks on a single activity station in a 24-h period. However, of the 491 stations where dingo spoor was recorded, more than 85% had less than four dingo tracks. We are certain that some dingo tracks were never recorded because vehicles or cattle had removed their traces, yet we could still count the remaining tracks and discern our mark.

Non-target animals, predominantly birds (corvids), removed 110 FAS discs and 205 BM baits over the course of the 2700 station-days exposure. In all, 21 activity stations were destroyed, either by vehicular traffic or cattle, in the 1350 station-days exposure.

The daily visitation and cumulative means recorded by the three indices at the three density levels are shown in Fig. 1. At each density level the BM index and, to a lesser extent, the FAS and activity indices indicated a trend for dingo activity to increase. This trend, however, was negligible and represented a change of less than 10% in the cumulative means after four days.

The dingo abundance indices calculated for each method at each density level are shown in Fig. 2. Assuming that the laying of poisoned baits caused an incremental decrease in dingo abundance, indices sometimes showed inconsistent results suggesting that abundance had increased.

During the first baiting period, 23 baits were removed by dingoes and one bait was visited and left undisturbed. A total of 45 baits was removed during the second baiting and 30 were visited and not disturbed.

Pearson's correlation coefficients among the three relative abundance indices were each greater than 0.85 (Table 1), indicating that all three indices had a high level of agreement in tracking daily changes in dingo activity.

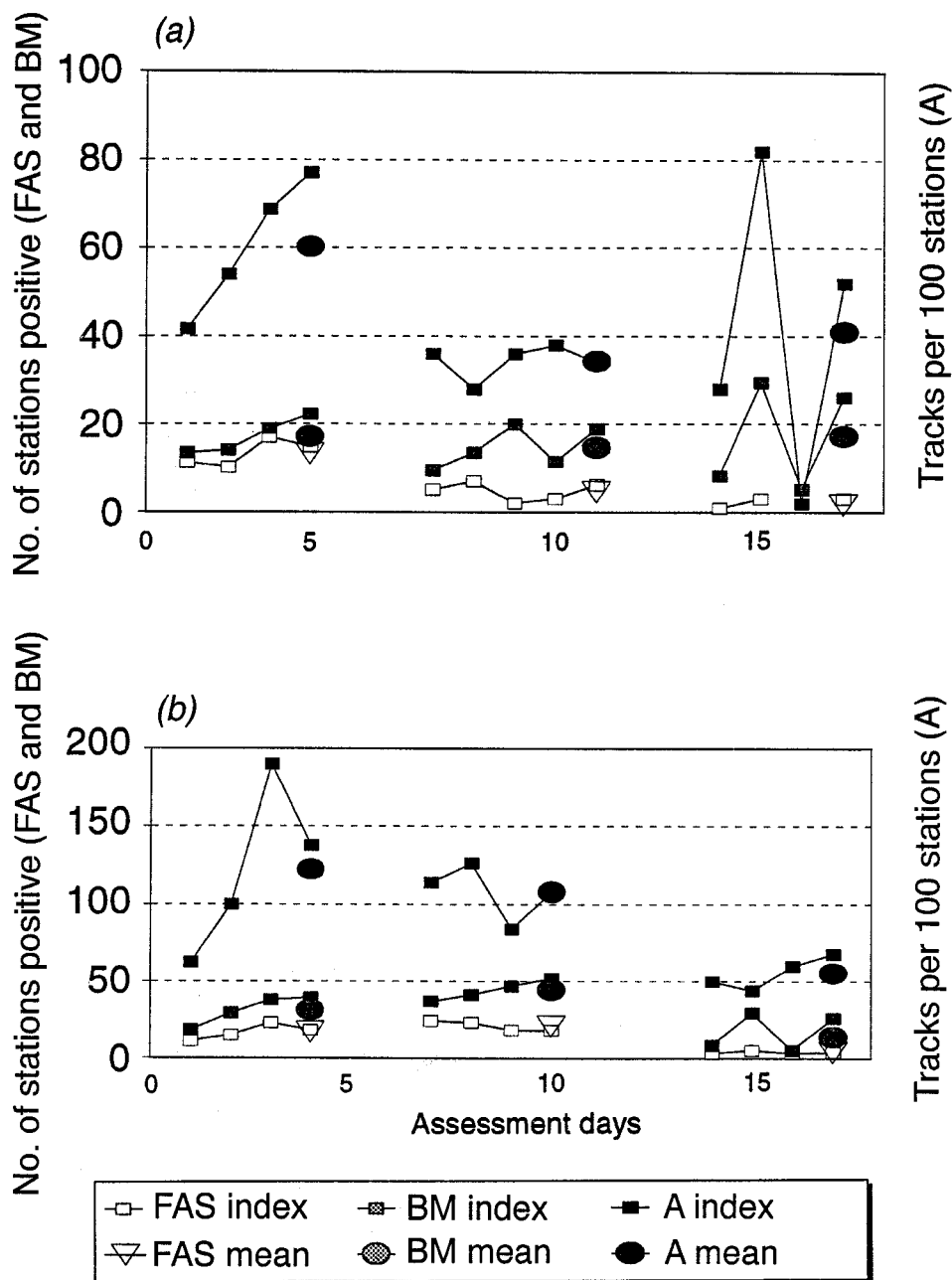


Fig. 1. Daily visitation rates to tracking stations and cumulative means of dingo activity at three density levels (before baiting and after each of two baiting periods), as measured by the Fatty Acid Scent (FAS), Buried Meat (BM) and activity (A) indices at (a) the north transect and (b) the south transect.

When observations were grouped into 1-, 2-, 3- and 4-day intervals, significant differences in the proportion of positive stations ($P < 0.0001$) existed between the methods of recording activity (Table 2). Irrespective of the time grouping, the activity index resulted in a substantially

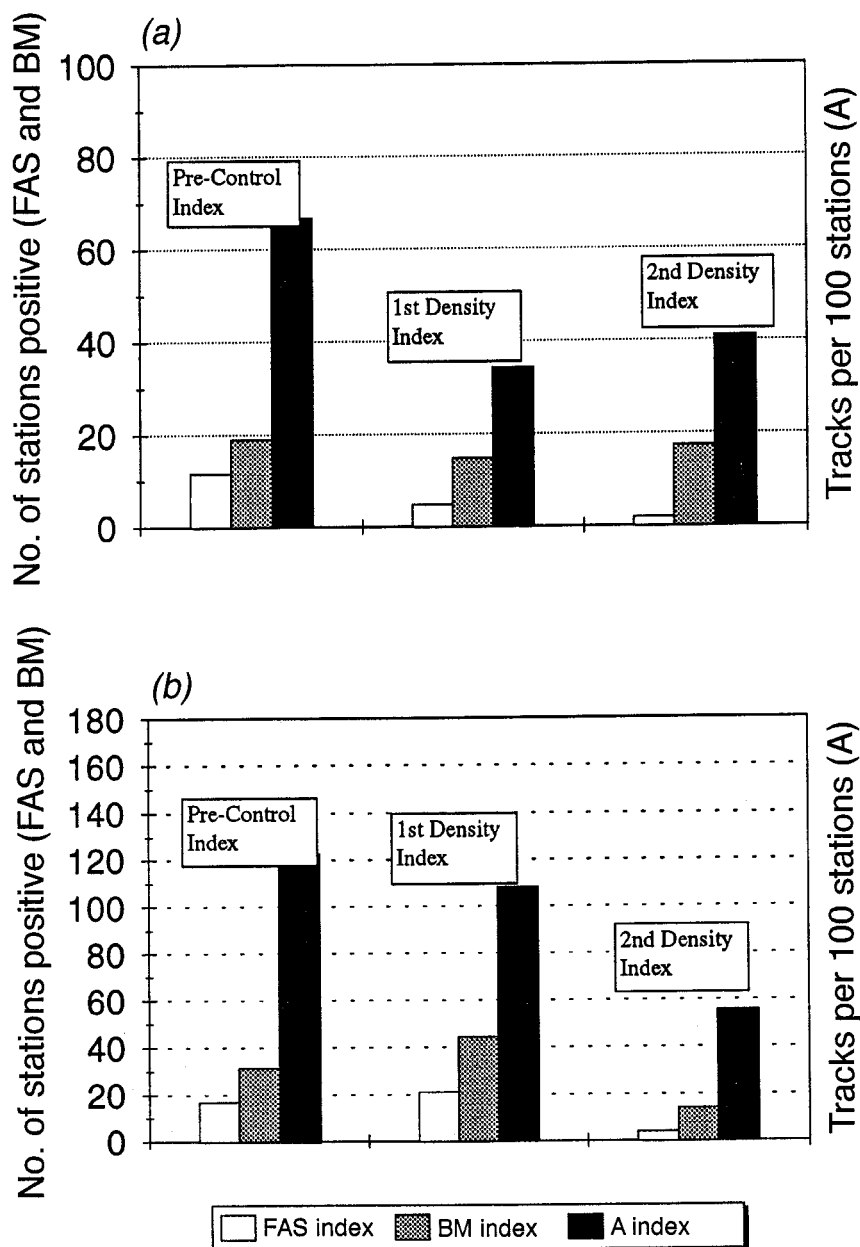


Fig. 2. Relative abundance of dingoes based on activity as measured by the Fatty Acid Scent (FAS), Buried Meat (BM) and Activity (A) indices at three density levels (before baiting and after each of two baiting periods) at (a) the north transect and (b) the south transect.

higher proportion of positive readings than did the other two indices. In each case, the BM index registered more positive readings than did the FAS index. These results were consistent for both sites.

Table 1. Pearson's correlation coefficients between the three relative abundance indices at three different density levels, with the corresponding *P*-value for testing difference from zero in parentheses

Index	BM	FAS
Activity	0.847 (0.033)	0.910 (0.012)
BM		0.899 (0.015)

Table 2. Results of Cochran's *Q*-test evaluating the theoretical sensitivity of the three indices if tracking stations were assessed at 1-, 2-, 3- and 4-day intervals

Significant differences ($P < 0.0001$) exist between all pairs in respect to recording interval and index method

Recording interval (days)	Proportion positive			χ^2 (d.f. = 2)
	Activity	BM	FAS	
North site				
1	0.24	0.16	0.05	107.21
2	0.40	0.26	0.07	102.02
3	0.46	0.32	0.11	53.52
4	0.60	0.37	0.13	76.57
South site				
1	0.44	0.28	0.12	193.36
2	0.61	0.38	0.17	139.28
3	0.72	0.44	0.22	82.37
4	0.81	0.55	0.28	87.85

Discussion

The FAS index was significantly correlated with the other two indices and reflected changes in dingo activity, yet the FAS disc appeared to attract, to the tracking station, only a small proportion of the dingo population potentially exposed (compare the number of positive FAS stations with the number of positive BM or activity stations in Fig. 2).

The comparatively low response rate by dingoes to the novel FAS attractant is consistent with the response reported for coyotes in the USA (Harris 1983) and suggests that dingoes exhibit a similar neophobic behaviour. Harris (1983) found that individual coyotes were less likely to visit novel FAS stations encountered inside their territories (a familiar area) than those encountered on the boundary or outside their territory (in an unfamiliar environment). Differences in the relative vulnerability of coyotes to capture devices, in relation to where the device was encountered relative to their territory boundary, has also been reported by Windberg and Knowlton (1990).

Thomson (1986) showed that similar behaviour may occur in dingoes. He found a 'disproportionate vulnerability of lone or young dingoes to poisoned meat baits than those that were members of social groups'. He attributed this to the poorer hunting success of these animals. However, it may also be true that lone dingoes and young dingoes that are not members of social groups are more likely to be outside a territory familiar to them and more likely to investigate baits.

Discounting any differences in the magnitude of the odour plumes from the two attractants and their respective presentation differences, we conclude from the dingoes' response rate to FAS and BM that dingoes may be more likely to investigate a familiar food attractant (e.g. kangaroo meat) than an unfamiliar odour.

If dingoes exhibit a behaviour similar to that of coyotes, as suggested by these data, then the FAS index in particular needs to be used with caution. The objectives of any study using the FAS relative abundance index should be examined to determine whether an index that may be potentially biased towards transient and non-territorial animals in the population may confuse or mask the real population parameters being investigated. Harris (1983) suggested that, as a novel odour becomes more familiar, previously neophobic or resident animals may subsequently investigate these odours.

FAS and BM indices both require a response by the target animal to an attractant. This response may be influenced by each animal's social status, nutrition and prior experience. Despite this, the three methods produced parallel results of changes imposed on the population, although there were significant differences in their relative sensitivities.

The BM index offers a food reward to those dingoes that investigate the tracking station and dig up the meat. In previous studies where fresh meat was compared with other unpoisoned bait substrata (Allen *et al.* 1989), there was no evidence that contagion, caused by learning, occurred. However, in Thompson and Fleming's (1994) unpoisoned fox population, and in this study, contagion was shown to occur, with daily visitation rates to BM stations generally increasing at each density level (Fig. 1). However, in the trials conducted by Allen *et al.* (1989), baits were seldom exposed for more than four consecutive days, whereas this trial extended over 21 consecutive days and the trials of Thompson and Fleming (1994) extended over 36 consecutive days.

From this perspective, although BM is more attractive to dingoes and results in higher response rates and greater sensitivity than the novel FAS, meat may artificially increase dingo activity and influence the BM index over time. This is not a positive attribute for a reliable index of dingo abundance. We predict that this effect is likely to be most significant where the same tracking stations, transect and bait type are used for many consecutive days.

As previously mentioned, not all of the tested indices showed the predicted decrease in the dingo population following baiting. In the north transect, two of the three indices (FAS being the exception) showed an increase in dingo activity following the second baiting, and, in the south transect, two indices (activity being the exception) showed an increase in dingo activity following the first baiting (Fig. 2).

The impact of baiting on dingo populations in this experiment should have been minimal and localised to the area immediately surrounding the transect where the baits were laid. Baiting appears to have stimulated activity of surviving members of dingo groups and promoted exploratory forays from neighbouring social groups. This increase in activity following baiting, although obviously not related to dingo abundance, was probably exacerbated by contagion (learning of the presence of buried meat) and season, May being the peak of the breeding season for dingoes (Thomson 1992a). If the objective of the experiment was to evaluate the impact of baiting on the population, baits should have been distributed over a wider area and the post-baiting assessments delayed several days, sufficient for the survivors to re-establish normal activity patterns.

Why the three indices did not respond similarly to the increased dingo activity is not clear. We suspect that the increased activity in the south transect, measured by FAS and BM after the first baiting, is due to the relatively small numbers of dingoes killed (13 baits were removed by dingoes in the first baiting and 31 in the second baiting in this area), and the escalating dingo activity (contagion) that was occurring in this area (Fig. 1).

Numbers of dingo tracks were recorded at activity stations, rather than just a positive response; this may explain why the activity index did not parallel the FAS and BM indices in this instance. When there are multiple animals visiting FAS or BM tracking stations, baiting

could reduce the population size and the number of tracks at activity stations, yet the surviving dingoes continue to provide no fewer positive responses at the FAS and BM stations. Recording the number of dingoes visiting FAS and BM stations could have theoretically improved the sensitivity of the BM and FAS indices and prevented this discrepancy. However, this is impractical because it is difficult to separate superimposed tracks.

In the north transect, the increase in dingo activity occurred after the second baiting and was recorded by the BM and activity indices. A total of 24 poisoned baits had been removed by dingoes at this stage. After the second baiting in the north transect, daily counts of dingo activity fluctuated wildly for all three indices (Fig. 1). Ranges were 2–82, 5.3–29.5 and 0–3.1 after the second baiting, compared with 28–38, 9.5–20 and 2.1–7.1 after the first baiting, for the activity, BM and FAS indices, respectively. Large daily fluctuations in activity after baiting may have been produced by neighbouring social groups making exploratory forays into the recently vacated (baited) area. Such forays have been described by Thomson *et al.* (1992) and often precede subsequent immigration of neighbouring dingoes. The FAS index was at this stage very low (1.8, compared with 17.3 and 41 for BM and activity indices respectively) and did not detect the increased activity.

While Thompson and Fleming's (1994) use of buried meat is very similar to that in this study, differences exist as to when the arbitrary cut-off point was reached: when the daily visitation rate to tracking stations levelled off (i.e. became asymptote) (Thompson and Fleming 1994), or when the change in cumulative mean fell below 10% (this study). One potentially significant difference is the time and effort required to obtain an abundance index, an asymptote taking considerably more days to generate and identify. Although the asymptote may remove some of the effects of contagion (Thompson and Fleming 1994), the index (the levelling-off point) is likely to be influenced by food availability. When seasonal conditions are poor and the dingo population physiologically stressed, contagion is likely to be more pronounced, producing a higher abundance index than when alternative food resources are readily available. Used in isolation, the activity index is unlikely to be affected by contagion by learning; therefore, an asymptote would not occur and an abundance index would never be generated.

The number of BM baits and FAS discs removed by birds in this study was surprising, even though they had negligible effect on the data analysis. Allen *et al.* (1989) showed that, by burying meat baits, removal of them by birds could be avoided. Habituation was occurring with birds removing baits or discs from the same stations every day. This, too, may have been a consequence of the 21-day period over which baits were replaced. No decline was observed in the number of baits or discs removed by birds following the laying of 1080-poisoned meat baits. However, this is not unexpected given the much higher tolerance birds have to 1080, compared with that of dingoes (McIlroy 1986).

One practical limitation of the BM index is the transport and handling of quantities of fresh meat in the field. To prevent spoilage, meat has to be refrigerated or obtained every few days. This requirement compromises the practical usefulness of this index for remote locations. Alternatively, meat baits may be dried prior to commencement of the study.

The activity index, which is based on counting the daily movement of animals over a tracking station, is unlikely to influence normal dingo activity. Occasionally, dingoes were inquisitive of the activity stations and inspected them thoroughly. This meandering behaviour of an individual dingo was recorded as a solitary animal, even though it may have crossed the station several times in its investigation. We did not, however, observe any evidence to suggest that dingoes actively avoided activity stations.

Because the movement of dingoes along tracks will often be attributable to maintenance of territory (Harden 1985; Corbett 1995) seasonal behavioural patterns may occur. While this does not compromise *per se* the value of any of the relative abundance indices used, studies that involve comparisons of treatment effects based on population responses, using any of the abundance indices tested, should be made during the same season.

All the indices evaluated are susceptible to inclement weather (strong wind and rain), vehicular traffic and excessive livestock activity over the tracking surface. For dingoes, the activity index is particularly vulnerable. Dingoes, more often than not, pad directly along the wheel tracks on a dirt road; when vehicles and livestock subsequently pass by, some tracks are obliterated. Similarly, when several dingoes are present, separating their superimposed tracks can be difficult.

Even when activity stations were analysed as if they were recorded as either positive or negative responses, the activity had a far greater sensitivity than those of the BM or FAS indices. The BM index tended to have a response rate about 2–3 times that of the FAS index, and the activity index had a response rate about 1.5 times greater than that of the BM index and three times that of the FAS index (Table 2).

Bait Shyness

In all, 68 poisoned baits were removed or consumed by dingoes in this project. Of particular interest is the higher incidence of dingoes visiting but not eating poisoned baits during the second baiting. Thompson and Fleming (1994) and others (Linhart 1964; Trehwella *et al.* 1991) reported similar responses by foxes following baiting in their experiments. It follows that the first 1080 baiting in this experiment removed predominantly bait-prone and naïve dingoes and, at the second 1080 baiting, the more neophobic and bait-shy portion of the dingo population became noticeable.

Optimum Period between Assessments

We evaluated the sensitivity of the three methods as if they were assessed at 1-, 2-, 3- and 4-day intervals by assuming that all the spoor recorded on stations assessed daily would be the same as if the stations had been assessed after two, three or four days (Table 2). Under 'normal' field conditions, spoor is erased and disappears over time. Thus, an observer could not be expected to distinguish all the spoor on tracking stations assessed every few days with equal clarity to the information recorded from daily inspections over the same period. Consequently, assessments made at 2- or 3-day intervals reduce the variability of daily counts, but come with some loss of sensitivity.

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